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Helmut Herwartz* and Fang Xu†

Abstract: What does the saving-investment (SI) relation really measure and how should the SI relation be measured? These are two of the most discussed issues triggered by the so called Feldstein-Horioka puzzle. Based on panel data we introduce a new variant of functional coefficient models that allow to separate long and short to medium run parameter dependence. We apply the latter to uncover the determinants of the SI relation. Macroeconomic state variables such as openness, the age dependency ratio, government current and consumption expenditures are found to affect the SI relation significantly in the long run.

Keywords: Saving-investment relation, Feldstein-Horioka puzzle, functional coefficient models,
JEL Classification: C14, C23, E21, E22

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1 Introduction

"How internationally mobile is the world's supply of capital?" This is the question investigated by Feldstein and Horioka (1980), henceforth FH (1980). By means of a between regression for OECD countries, FH (1980) document a strong correlation linking the domestic investment and saving, which is argued to be at odds with capital mobility. Following FH (1980) one would expect that under perfect capital mobility the correlation between a country's saving and investment ratio should be small. As such the diagnosed high correlation is in contrast to established theoretical frameworks in open economy macroeconomics and also to the believe that capital markets have experienced substantial liberalization.

The so-called "Feldstein Horioka puzzle" (FH puzzle) has provoked a lively discussion in both theoretic and empirical literature. Two of the most investigated questions are: What does the saving-investment relation really measure and how should the saving-investment relation be measured? To answer the first question, various determinants of the SI relation have been suggested in the theoretical literature such as population growth (Obstfeld 1986), the intertemporal budget constraint (Coakley, Kulasi and Smith 1996, Taylor 2002), output fluctuations in non-traded goods (Tesar 1993), or current account targeting (Artis and Bayoumi 1992). Since the intertemporal budget constraint seems to be one of the most convincing reasons for a high SI relation, most recent empirical investigations for the SI relation are concentrating on a potential cointegration relation between saving and investment.[1] Thereby, error correction models are suggested as the suitable framework to measure the SI relation.[2] However, no unique evidence for a cointegration relation between saving and investment is found. Compared to the abundant empirical investigations for the intertemporal budget constraint, empirical contributions linking all other determinants of the SI relation are rather scarce. A few exceptions and identified factors are Summers (1988) (government budget balance), AmirKhalkhali, Dar and AmirKhalkhali (2003) (government size), Kasuga (2004) (financial structures) and Sachsida and Caetano (2000) (the variability between external and domestic saving). Furthermore, in these contributions there exists no unique model to measure the SI relation along with potential determinants.

In this paper, we suggest a new semiparametric approach to investigate the determinants of the SI relation. The latter is derived as a bivariate generalization of functional coefficient models (Cai, Fan and Yao 2000). We adopt a new bootstrap based venue of inference which is suitably immunized against adverse effects of (mild) under- or oversmoothing of semiparametric functional estimates. To identify potential determinants of the SI relation the formalized semiparametric model is suitable to cope with cross sectional

[1] Abbott and Vita (2003), Gulley (1992), Ho (2002a), Ho (2002b), Leachman (1991), Lemmen and Eijffinger (1995), Haan and Siermann (1994), Miller (1988), Vita and Abbott (2002).

[2] Bajo-Rubio (1998), Coiteux and Olivier (2000), Jansen (1996), Jansen and Schulze (1996), Jansen (1998), Moreno (1997), Özmen and Parmaksiz (2003b), Özmen and Parmaksiz (2003a), Pelagidis and Mastroyiannis (2003), Pelgrin and Schich (2004), Schmidt (2001), Sinha and Sinha (2004), Taylor (1996), Taylor (1998).

heterogeneity, time and factor dependence. It allows to separate deterministic from measurable economic conditions characterizing the empirical SI relation over time. Moreover, it allows to distinguish long and short run factor impacts on the SI relation.

We analyze annual data spanning the period 1971 to 2002 for various (partly overlapping) cross sections characterizing the world economy, developing countries, the OECD, the EU and the Euro area. With respect to the choice of potential factor variables we rely on recent studies by Edwards (1995), Debelle and Faruqee (1996), Milesi-Ferretti and Razin (1997), Milesi-Ferretti and Razin (1998), Masson, Bayoumi and Samiei (1998), and Chinn and Prasad (2003). The employed factor variables allow a classification into three groups: Potential determinants of saving, investment or the current account balance and factors describing the integration of goods and financial markets. In addition, the scope of variables measuring the dependence of the SI relation on country size is addressed.

From functional coefficient models, an economies' degree of openness, its age dependency ratio and government current and consumption expenditures are identified to have a significantly negative influence on the SI relation in the long run. Besides, countries with high GDP (measuring the effect of country size) are more likely to have a high SI relation. According to these results, the interpretation of a high SI relation as a signal for low capital mobility in FH (1980) has to be treated with care. As a consequence, empirically high SI relations could reflect goods market friction, demographic development or fiscal consolidation rather than being puzzling.

The remainder of the paper is organized as follows: In the next Section we briefly sketch some core theoretical contributions provoked by FH (1980). In Section 3 we initiate our empirical analysis by highlighting that the empirical SI relation has experienced some weakening over more recent time periods and might be driven by measurable economic factors. Given that the link between domestic saving and investment is likely heterogeneous over time as well as factor dependent we introduce a semiparametric approach to evaluate the SI relation in Section 4. We derive the new framework from univariate functional coefficient models, and discuss briefly model representation, estimation, implementation and inferential issues. Empirical results obtained from the latter venue of modeling are provided in Section 5. Section 6 summarizes briefly our main findings and concludes. More detailed information on the investigated (cross sections of) economies and factors is given in the Appendix.

2 Economic models explaining a high SI relation

In this section, we sketch briefly some of the leading explanations offered in macroeconomics to explain a high SI relation. For a detailed review over the literature on the FH puzzle the reader may consult Coakley, Kulasi and Smith (1998). From the viewpoint of economic theory, firstly, general equilibrium models have been constructed that allow a high SI relation in response to exogenous shocks under high or perfect capital mobility. By means of a life-cycle model Obstfeld (1986) demonstrates that, given a rise in the population growth rate, both the saving and the investment ratio increase. Mendoza (1991) constructs a real-business-cycle model of a small open economy with moderate adjustment costs and small variability and persistence of technological shocks. The latter turns out to be consistent with a positive correlation between domestic saving and investment, although financial capital is perfectly mobile.

Secondly, the stationarity of the current account balance implied by the long run intertemporal budget constraint (solvency constraint) could induce a high SI relation. By construction, saving minus investment equals the current account balance. Thus, a close SI relation might reflect stationarity of the current account. Introducing a market determined risk premium on borrowing, Coakley, Kulasi and Smith (1996) show that the long run solvency constraint implies a stationary current account. For the case of a simple Solovian economy with stochastic growth, Taylor (2002) demonstrates that stationarity of the current account is a sufficient condition for the long run intertemporal budget constraint to hold. In this vein of economic models a high SI association reflects the solvency constraint, but not necessarily capital immobility. However, the empirical evidence on the stationarity of current account balances is weak or mixed.

In the third place a high SI relation may be due to a government targeting the current account balance. Artis and Bayoumi (1992) argue that the current account balance was an important target for monetary policy in the 1970s, but not in the 1980s. This policy change appears to correspond to a reduction in the SI relation among OECD countries in the 1980s.

A recent perspective on the latter two issues that takes the bounded nature of current account measures in unit root tests into account is provided in Herwartz and Xu (2006b). They argue that the current account balance is a bounded non-stationary process and empirical rejections of the unit root hypothesis might be due to the existence of bounds in the sense of policy controls or crises. Thus, the high SI relation might be partially caused by the existence of the bounds on the current account imbalances.

Finally, the goods market, not the capital market, may be seen as the binding constraint linking domestic saving and investment. From this perspective, Tesar (1993) demonstrates that a model with stochastic fluctuations in the output of non-traded goods is consistent with a high SI association. In case non-traded goods account for a significant share of total output, consumer preferences over traded and non-traded goods and over the intertemporal allocation of consumption may introduce low cross-country correlations of aggregate consumption and an optimal portfolio biased towards claims on domestic output. Describing the so–called consumption correlations puzzle (Backus, Kehoe and Kydland 1992) and the home-bias portfolio puzzle (French and Poterba 1991), the latter effects are in line with a high SI relation. Comparably, Obstfeld and Rogoff (2000) demonstrate that moderate transactions costs of international trade may cause a substantial difference in real interest rates in spite of full financial market integration. In turn, real interest rate differentials might give rise to a high SI relation.

3 Preliminary analyses

Having reviewed theoretical approaches to modeling the SI relation, we introduce the data and motivate the use of alternative cross sections in this section. Furthermore, stylized features of the empirical SI relation, as e.g. its downward trending behavior, will be illustrated by means of standard between regressions as in FH (1980) and time dependent regressions as adopted by Sinn (1992) or Blanchard and Giavazzi (2002). Finally, the issue of factor dependence is addressed.

3.1 The data

In the empirical literature on the SI relation, most authors concentrate on one or two specific cross sections such as OECD members, EU countries, the Euro area, large or less developed economies. In this paper, we investigate a set of specific cross sections, and a general cross section sampled from all over the world and containing as many economies as possible conditional on data availability. The latter is one of the largest cross sections that has been considered to analyse the SI relation. Distinguishing numerous specific cross sections will be useful to reconsider former analyses relating the SI relation e.g. to the degree of market integration or the state of development. The large cross section promises a global view on descriptive features of the correlation between domestic saving and investment and its underlying determinants.

We investigate the SI relation with seven alternative (partly overlapping) cross sections using annual data from 1971 to 2002 drawn from the World Development Indicators CD-Rom 2004 published by the World Bank. These cross sections are composed as follows:

1) The first and most comprehensive sample covers 97 countries from all over the world (W97), for which most observations of the saving and investment ratio from 1971 to 2002 are available. For 6 countries data for 2002 are not available. These missing values are estimated by means of univariate autoregressive models of order 1 with intercept. Although data for Sao Tome and Principe and Lesotho are published, these two countries are not included owing to an outstandingly high negative saving ratio prevailing over quite a long period. A list of all 97 countries contained in W97 is provided in the Appendix.

2) All OECD countries except Czech Republic, Poland, Slovak Republic and Luxembourg comprise the second cross section and is denoted with O26. The first three

countries are not included due to data nonavailability. Luxembourg is often excluded in empirical analyses of the SI relation owing to presumably peculiar determinants of its savings.

3) The third sample we consider covers 14 major countries of the European Union (E14), which are the O26 countries without Australia, Canada, Hungary, Iceland, Japan, Korea, Mexico, New Zealand, Norway, Switzerland, Turkey and the US. Contrasting this subgroup with O26 may reflect the EU effect on the SI relation.

4) As the fourth cross section 11 Euro area economies excluding Luxembourg (E11) are investigated. E11 differs from E14 by exclusion of Denmark, Sweden and the UK. In the Euro area, there is no exchange rate risk and financial markets should be more integrated in comparison with the remainder of the EU.

5) To offer a 'complementary' view at the link between market integration and the SI relation, we investigate a fifth cross section defined as O26 minus E11. Here we focus on weaker forms of market integration and try to isolate their impact on the SI relation.

6) Conditioning the SI relation on the state of economic development has become an important avenue to solve the FH puzzle. Therefore we analyze a sixth cross section that collects less developed economies. The latter is obtained as W97 minus O26 and denoted in the following as L71.

7) Finally, for completeness and to improve on the comparability of our results to FH (1980) we will also consider the cross section employed in their initial contribution (F16). The latter comprises 16 OECD countries namely O26 excluding France, Hungary, Korea, Mexico, Norway, Portugal, Spain, Switzerland and Turkey.

3.2 Between regressions

To investigate the SI relation, FH (1980) make use of a between regression

$$\overline{I_i^*} = \alpha + \beta \overline{S_i^*} + e_i, \quad i = 1 \ldots N, \tag{1}$$

where $\overline{I_i^*} = 1/T \sum_{t=1}^{T} I_{it}^*$, $\overline{S_i^*} = 1/T \sum_{t=1}^{T} S_{it}^*$, $I_{it}^* = I_{it}/Y_{it}$ and $S_{it}^* = S_{it}/Y_{it}$, with I_{it}, S_{it} and Y_{it}, $t = 1, \ldots, T$, denoting gross domestic investment, gross domestic saving and gross domestic product (GDP) in time period t and country i, respectively. Implementing the between regression in (1) with annual data covering the period 1971 to 2002, we obtain the results shown in panel A of Table 1. Between regression estimates are significantly positive in all cross sections except E11 and E14. Excluding the two latter cross sections from model comparison between regressions offer degrees of explanation between 52% (O26) and 83% (O15). Following the arguments in FH (1980) a significantly positive SI relation in W97 is not surprising. Some patterns of capital market segmentation are likely over a group of 97 economies sampled from all over the world. From a global perspective capital mobility is limited 'on average'. For E14 and E11, the coefficient estimates are insignificant and thereby confirm the EU and Euro effect. Capital mobility is high among EU countries and even higher in the Euro area. In F16, both the estimated SI relation (0.62) and the degree of explanation (0.58) are smaller for the period 1971 to 2002 compared to the corresponding results (0.887 and 0.91) given in FH (1980) for the period 1960 to 1974. The latter finding is consistent with the presumption that capital mobility has increased over time. Furthermore, it could be shown that the estimated SI relation becomes insignificant in F16 if Japan, the UK and the US are excluded, thereby signalling a large country effect.

Given the weakened evidence in favor of a large or even significant SI relation in more recent samples in comparison with FH (1980), it is sensible to check the robustness of the previous between regression results by means of two equally sized sub-samples, covering the periods 1971 to 1986 and 1987 to 2002, respectively. Between regression results obtained for these two subperiods are documented in panels B and C of Table 1. It can be seen that the estimated SI relation has decreased in all cross sections. This evidence points to some variation of the SI relation and, moreover, is consistent with the generally improving integration of capital and goods markets. Furthermore, the between estimates are insignificantly different from zero in E14 and E11 for both subperiods. Although the SI relation in OECD economies (O26, F16, O15) is still significantly different from zero, it is much smaller for the more recent period. The degree of explanation achieved by between regressions for the second subset is lower than for the first, and varies between 26% (F16) and 68% (O15) when E11 and E14 are excluded. It is worthwhile mentioning that as an alternative to between regressions pooled regression models deliver results which are qualitatively identical to those reported for the between regressions. We do not provide pooled estimates in detail for space considerations.

In the light of the latter results one may conjecture that the FH puzzle is not such a big puzzle anymore when concentrating on more recent time windows. In a similar vein, using data for 12 OECD countries from 1980 to 2001, Coakley, Fuertes and Spagnolo (2004) show the insignificance of the SI relation by means of nonstationary panel models. Blanchard and Giavazzi (2002) also document a small SI relation in a pooled regression for the EU area using the sample period 1991 to 2001. From a statistical as well as economic viewpoint, however, potential time variation of the SI relation provokes some subsequent issues. With regard to statistical aspects it is not clear in how far conclusions offered by (misspecified) time homogeneous econometric models are spurious or robust under respecification of the model. From an economic perspective it is tempting to disentangle the economic forces behind the observed decreasing trend in the SI relation. With regard to the latter aspect it is of particular interest to separate deterministic time features from measurable economic factors driving the SI relation. The next paragraph will underscore that the SI relation is likely not homogenous within the two subsamples considered so far but time varying throughout.

3.3 Time dependent SI relations

To address the time variation of the SI relation in some more detail, we employ a sequence of (time specific) cross sectional OLS regressions as proposed by Sinn (1992) or Blanchard and Giavazzi (2002):

$$I^*_{it} = \alpha_t + \beta_t S^*_{it} + e_{it}, \quad i = 1 \ldots N. \tag{2}$$

Time varying slope estimates, $\widehat{\beta}_t$, $t = 1971, \ldots, 2002$, obtained from model (2) for the three non-overlapping cross sections (L71, O15 and E11) are shown in Figure 1 jointly with corresponding 95% confidence intervals. Eyeball inspection confirms that the SI relation has decreased over time in all cross sections. It has declined from around 0.39 to 0.18 in L71 (similarly in W97), from 0.8 to 0.2 in O15 (O26 and F16) and from 0.5 to zero in E11 (E14). Regarding E14 and E11 our results are in line with Blanchard and Giavazzi (2002). A sharp reduction of $\hat{\beta}_t$ between 1975 and 1980 is found for F16, E14 and E11. This evidence might be due to the fact that many industrialized economies experienced current account deficits in this period. The latter might mirror the effects of oil price shocks in the late 1970s. According to Sachs (1981), however, changes in investment opportunities rather than oil price changes dominated the medium run behavior of current accounts in the 1970s.

3.4 Factor dependence - profiles of estimated SI relations

Given the apparently decreasing trend of the SI relation documented in the last two subsections, it is tempting to investigate if the decrease of empirical SI relations is a purely deterministic feature or could be explained by (measurable) economic conditions. Providing a first view at the determinants of empirical SI relations we perform cross sectional regressions of the following type:

$$\hat{\beta}_i = \gamma_0 + \gamma_1 \bar{w}_i + e_i, \quad i = 1, \ldots N, \tag{3}$$

where $\overline{w}_i = 1/T \sum_{t=1}^{T} \widetilde{w}_{it}$ is a measure of some factor characterizing the i-th member of the cross section. The dependent variable $\hat{\beta}_i$ in (3) is the slope estimate obtained from cross section specific regressions,

$$I^*_{it} = \alpha_i + \beta_i S^*_{it} + e_{it}, \quad t = 1, \ldots T. \tag{4}$$

In case $\hat{\gamma}_1$ differs significantly from zero we regard the respective factor to affect the SI relation. The regression in (3) takes a cross sectional view at the determinants of the

SI relation. The latter is justified in the light of highly significant and quantitatively substantial panel heterogeneity diagnosed in Herwartz and Xu (2006a).

As a particular caveat of the regression in (3) one may point out that the dependent variables are not observed but (unbiased) estimators from some first step regression. As a more direct variant to detect factor dependence using observable regressands, one may regard a model

$$I_{it}^* = \alpha_i + \gamma_0 S_{it}^* + \gamma_1 \bar{w}_i S_{it}^* + e_{it} \quad (5)$$

that is obtained from substituting $\beta_i = \gamma_0 + \gamma_1 \bar{w}_i$ in (4). Running the latter regression we find that the point estimates for γ_1 are rather close to those obtained from (3). We believe, however, that owing to potential cross sectional heterogeneity and autocorrelation of model disturbances e_{it} in (5) estimation uncertainty is easier to control in the cross sectional regression (3). We refrain from providing detailed results for the disaggregated regression model in (5) for space considerations.

We find two factors for which a significant influence is diagnosed for at least two of the non-overlapping cross sections, L71, O15 and E11. Results from corresponding profile regressions are reported in Table 2. We discuss them in turn:

- A negative impact of the age dependency ratio on the cross sectional SI relation is diagnosed over 4 OECD samples and W97. The higher the ratio of dependents to the working-age population, the less is, ceteris paribus, the domestic saving. This might lead to the disconnection of domestic saving and investment.
- The openness ratio has a significantly negative effect on the SI relation for OECD economies and less developed countries. More open economies have more integrated good markets which in turn might lead to a weaker SI relation. Separating the openness ratio into the ratios of exports and imports to GDP, significantly negative effects on the SI relation are confirmed for both components.

Apart from parameter significance documented in Table 2, the detected cross section patterns are mostly uniform in the sense that the diverse profile regressions indicate the same direction of potential state variables affecting the SI relation. As a further result it is worthwhile to point out that specific factors suggested by economic theory as, for instance, population growth, country size or fiscal variables, fail to describe the cross sectional pattern of SI relations significantly. The latter failure of significance, however, may also be addressed to a false presumption of time homogeneity of the SI relation or the factor state ($\bar{w}_i$) or both. When performing a surface regression by regressing $\hat{\beta}_i$ simultaneously on the explanatory factors listed in Table 2, it turns out that owing to multicollinearity only two factors remain to have significant explanatory power. Such surface regressions detect the age dependency ratio and one of the trade related measures (openness, exports, imports) to explain estimates $\hat{\beta}_i$ significantly.

4 Functional coefficient models

The preceding analyses have shown that the link between domestic saving and investment exhibits some downward trending behavior. Moreover, profile regressions reveal that the correlation between domestic saving and investment may be explained conditional on some economic factor variables, which confirms the country specific nature of the SI relation as argued by Herwartz and Xu (2006a). Given the likelihood of parameter variation over two data dimensions, all empirical approaches followed so far carry the risk of providing biased results since at most one dimension of potential parameter dependence has been taken into account. From the latter observations, one may refrain from modeling the SI relation by means of econometric specifications presuming some restrictive form of (cross sectional or time) homogeneity or state invariance. As a consequence one may alternatively opt for local models where the parameters of interest are given conditionally on some economic state variable measured over both dimensions of the panel. For the latter reasons we will adopt semiparametric models that can be seen as a bivariate generalization of functional coefficient models as introduced by Cai, Fan and Yao (2000). A further merit of this approach and its local implementation is that it might give valuable information on the accuracy of the restrictive nature of parametric models. In the following we briefly sketch the functional coefficient model, it's estimation, implementation and inferential issues.

4.1 Model representation

To discuss model representation we start, for convenience, with a one dimensional factor model fitting into the framework introduced by Cai, Fan and Yao (2000). In a second step the bivariate state dependent model, as employed in this work, will be provided.

Consider the following semiparametric extension of a pooled regression:

$$\begin{aligned} I^*_{it} &= \alpha(w^{(i)}_{it}) + \delta(w^{(i)}_{it})t + \beta(w^{(i)}_{it})S^*_{it} + e_{it} \\ \equiv y_{it} &= x'_{it}\boldsymbol{\beta}(w^{(i)}_{it}) + e_{it},\ \boldsymbol{\beta}(\bullet) = (\alpha(\bullet), \delta(\bullet), \beta(\bullet))'. \end{aligned} \tag{6}$$

The model in (6) formalizes the view that the SI relation responses to (changes of) some underlying factor, $w^{(i)}_{it}$, characterizing the state of economy i. The inclusion of a deterministic trend term in (6) is thought to disentangle deterministic features of the SI relation from factor dependence. To measure economic states it is natural to represent the factor in some standardized form so that cross sectional comparisons are facilitated. Owing to potential nonstationarity of the time path of a particular factor variable measured for a specific cross section member, we consider standardized factors

$$w^{(i)}_{it} = (\widetilde{w}_{it} - \hat{w}^{(hp)}_{it})/\sigma_i(gap(w)). \tag{7}$$

In (7) $\hat{w}^{(hp)}_{it}$ is the long run time path of a particular factor variable as obtained from applying the Hodrick-Prescott (HP) filter (Hodrick and Prescott 1997) to $\widetilde{w}_{it}$, $t = 1, \ldots, T$.

Accordingly, the process $\widetilde{w}_{it} - \hat{w}_{it}^{(hp)}$ describes the 'factor gap' for economy i having unconditional (cross section specific) variance $\sigma_i^2(gap(w))$. To implement (7) with yearly factor observations we set the HP smoothing parameter to 6.25 as recommended by Ravn and Uhlig (2002). Note that the standardized 'factor gap' as defined in (7) has an unit unconditional variance. As an alternative for $\hat{w}_{it}^{(hp)}$ to measure a factor's long run time path, one may a-priori also consider a cross sectional mean, i.e. $\bar{w}_i = 1/T \sum_{t=1} \widetilde{w}_{it}$. In case a particular factor variable is nonstationary, however, it is not clear what $\bar{w}_i$ actually measures and, as such, it will not be representative for the factor over the entire sample period. In the opposite case of a stationary factor variable, $\bar{w}_i$ is an efficient approximation of the factor's 'steady state' but the efficiency loss implied by applying the HP filter might be moderate. Since controlling the time series features of diverse factor variables over a cross section as large as W97 is not at the core of our analysis, we prefer the HP filter as an approximation of a factor's long run time path.

Along the latter lines one may evaluate local SI relations conditional on scenarios where a particular factor variable for the i-th cross section member is above, close to or below its long run time path. Regarding, for instance, the ratio of exports plus imports over GDP as a factor, states of lower vs. higher 'openness' observed for a given economy over time could be distinguished to evaluate the SI relation locally. From the empirical features of the SI relation uncovered in Section 3.3, however, one may regard the model not only to depend on the location of the country specific factor relative to its long run time path but also on the factor's time features measured against other economies comprising the cross section. In a standardized fashion, the latter measure is $w_{it}^{(t)} = (\widetilde{w}_{it} - \bar{w}_t)/\sigma_t(\widetilde{w})$, where $\bar{w}_t$ and $\sigma_t(\widetilde{w})$ denote the empirical (time dependent) cross sectional mean, $\bar{w}_t = 1/N \sum_{i=1}^{N} \widetilde{w}_{it}$, and time specific standard error of $\widetilde{w}_{it}$, respectively. Note that $\bar{w}_t$, $t = 1, \ldots, T$, might be interpreted as a factor's long run time path measured over the cross section. In case the latter is as large as W97, $\bar{w}_t$ approximates a factor's global evolution over time. For instance, with regard to the openness variable, $\bar{w}_t$ is suitable to reflect the world wide trend towards global specialization and an intensified international exchange of goods. Since $\bar{w}_t$ is defined as an arithmetic mean over the cross section its local interpretation does not suffer from the potential of stochastic trends governing country specific factor processes. Generalizing the model in (6), both dimensions of a particular factor variable could be used to formalize a local view at the pooled regression model as

$$\begin{aligned} I_{it}^* &= \alpha(w^{(i)} = w_{it}^{(i)}, w^{(t)} = w_{it}^{(t)}) && (8)\\ &+ \delta(w^{(i)} = w_{it}^{(i)}, w^{(t)} = w_{it}^{(t)})t + \beta(w^{(i)} = w_{it}^{(i)}, w^{(t)} = w_{it}^{(t)})S_{it}^* + e_{it} \\ \equiv y_{it} &= x_{it}'\boldsymbol{\beta}(w^{(i)}, w^{(t)}) + e_{it} \\ &= x_{it}'\boldsymbol{\beta}(\omega) + e_{it}, && (9) \end{aligned}$$

with $x_{it} = (1, t, S_{it}^*)'$ and $\omega = (w^{(i)}, w^{(t)})$. The inclusion of a (local) trend parameter within the functional model allows to distinguish deterministic and time varying measurable economic conditions which are supposed to impact on the SI relation.

4.2 Estimation

To estimate the factor dependent parameter vector $\boldsymbol{\beta}(\omega)$ in (9) we proceed similar to a trivariate version of the Nadaraya Watson estimator (Nadaraya 1964, Watson 1964). The latter builds upon the following weighted sums of cross products of observations:

$$\mathcal{Z}(w^{(i)}, w^{(t)}) = \sum_{i=1}^{N}\sum_{t=1}^{T} x_{it}x_{it}' K_{i,h}(w_{it}^{(i)} - w^{(i)})K_{t,h}(w_{it}^{(t)} - w^{(t)}), \qquad (10)$$

$$\mathcal{Y}(w^{(i)}, w^{(t)}) = \sum_{i=1}^{N}\sum_{t=1}^{T} x_{it}y_{it} K_{i,h}(w_{it}^{(i)} - w^{(i)})K_{t,h}(w_{it}^{(t)} - w^{(t)}), \qquad (11)$$

where the components of the bivariate factor variable $\omega_{it} = (w_{it}^{(i)}, w_{it}^{(t)})$ have been defined previously as

$$w_{it}^{(i)} = (\widetilde{w}_{it} - \hat{w}_{it}^{(hp)})/\sigma_i(gap(w)),\ w_{it}^{(t)} = (\widetilde{w}_{it} - \bar{w}_t)/\sigma_t(\tilde{w}).$$

In (10) and (11) we denote $K_{\bullet,h}(u) = K_{\bullet}(u/h)/h$, where $K(\cdot)$ is a kernel function and h is the bandwidth parameter. From the moments given in (10) and (11), the semiparametric estimator is obtained as

$$\hat{\boldsymbol{\beta}}(\omega) = \hat{\boldsymbol{\beta}}(w^{(i)}, w^{(t)}) = \mathcal{Z}^{-1}(\omega)\mathcal{Y}(\omega). \qquad (12)$$

As it is typical for kernel based estimation, the choice of the bandwidth parameter is of crucial importance for the factor dependent estimates given in (12) (Härdle, Hall and Marron 1988). For bandwidth selection, we use Scott's rule of thumb (Scott 1992). Since the unconditional standard deviation of the factor variables over both data dimensions is (close to) unity by construction, the rule of thumb bandwidth is $h = (NT)^{-1/6}$. With regard to the kernel function, we use the Gaussian kernel, $K(u/h) = (2\pi)^{-1/2}\exp(-0.5(u/h)^2)$. Generally, NT is the number of observations available for the factor variable. For the practical implementation of the bivariate kernel estimator in the present case, we have to point out that owing to missing observations the actual panel used for estimation is unbalanced for numerous factor variables. For convenience, the latter feature of the panel is suppressed by the employed notation.

4.3 Implementation

The trivariate model formalized in (9) offers a local view at the SI relation conditional on a particular economic variable describing the state of an economy in two directions. As a consequence estimation results could be provided in terms of three dimensional graphs. Since our interest here is focussed on some overall impact of a particular factor on the SI relation, however, we will display estimation results from the model in (9) along particular paths of the state variables. The latter perspective has the advantage that estimation results can be provided in the familiar form of two dimensional functional estimates. To be explicit, estimates of the following local SI relations will be shown:

$$
\begin{array}{ll}
(i) & \hat{\beta}(w^{(i)} = v, w^{(t)} = -1, 0, 1), \\
(ii) & \hat{\beta}(w^{(i)} = 0, w^{(t)} = v),\ v = -2 + 0.1k,\ k = 0, 1, 2, \ldots, 40.
\end{array}
$$

Conditioning the evaluation of local estimates on states with either $w^{(i)} = 0$ or $w^{(t)} = 0$ provides different insights into the determinants of the SI relation that allow a classification into short and long run impacts. To get an intuition for the latter interpretations, we discuss the kernel based weighting schemes in (10) and (11) in some more detail.

- Short run determinants
  Conditional on $w^{(t)} = 0$ local SI relations are evaluated with putting higher weights on those members of a particular cross section that follow closely the cross sectional time trend ($\bar{w}_t$), as, for instance, the globally trending behavior towards an intensified exchange of goods. Similarly, conditional on positive (+1, say) or negative (−1) values of $w^{(t)}$, local SI relations are evaluated with those economies getting the highest weight which are above or below the factor specific trend. As a particular merit of the semiparametric approach it is noteworthy that the composition of the latter 'artificial' cross sections is time dependent, i.e. the weighting scheme picks up effects of a country falling behind or keeping up with the global perspective. Apart from the time varying kernel weight, $K_{t,h}(\bullet)$, it is the 'inner factor variation' around its country specific trend that enters the local weighting scheme for the given country ($K_{i,h}(\bullet)$). In the latter sense, conditional estimates of the SI relation exploit short run factor variation. Since short run factor dependence might differ according to a countries' position relative to the cross sectional average, it is tempting to compare various local estimates, conditioned upon $w^{(t)} = -1,\ 0,\ 1$ say.

- Long run determinants
  Conditional on $w^{(i)} = 0$, country specific weights $K_{i,h}(\bullet)$ are the highest for those observations where a particular factor realization in country i is close to the long run time path characterizing this particular economy. Varying in the same time the location of $w^{(t)} = -2, \ldots, 2$ allows to exploit 'outer factor variation' for quantifying local states of the SI relation. In this case, the chosen support of $w^{(t)}$ will subsequently put high kernel weight, $K_{t,h}(\bullet)$, on those economies which are below, close to or above a factor's overall time path. Since changes of the latter relative positions are likely to reflect long term economic conditions or policy strategies, local SI relations conditional on $w^{(i)} = 0$ are interpreted here as long run characteristics of the SI relation.

- An illustration
  The latter perspectives of factor variation are illustrated for the case of the openness ratio (measured in %) in Figure 2. The left hand side panel shows time series of the

openness ratio (dashed line) for all countries in O26 jointly with the time path of the average openness degree. The latter corresponds to $w^{(t)} = 0$. For three particular economies, Germany, the US and Japan, the openness ratio and it's corresponding country specific trend ($w^{(i)} = 0$) are shown in the medium panel as dashed and solid curves, respectively. When evaluating long run dependence of the SI relation on openness, factor realizations close to the latter trend enter the kernel regression with the highest weight. To estimate short run impacts of openness on the SI relation, factor variation around the long run trend (shown in right hand side panel of Figure 2) contributes to kernel based weighting while in the same time the relative location of a particular economy within the cross section is fixed. Given the openness measure as displayed in the medium panel of Figure 2, it is likely that inner German variations get a higher/lower kernel based weight than factor variations measured for Japan or the US conditional on a relatively high/low degree of openness ($w^{(t)} = 1/w^{(t)} = -1$).

4.4 Inference

Inference on state dependence of the SI relation may proceed conditional on some (approximation of) asymptotic properties of the Nadaraya Watson estimator (Nadaraya 1964, Watson 1964). In semi- and nonparametric modeling, bootstrap approaches have become a widely used toolkit for inferential issues. For univariate factor dependent regressions, Cai, Fan and Yao (2000) advocate a residual based resampling scheme to infer on factor dependence against a structurally invariant model specification. Owing to the relatively small sized available samples, residual based resampling might suffer from the instance that, in the boundaries of the factor support, functional estimates could become wiggly and at the same time residual estimates unreliably small. Moreover, residual estimation could be adversely affected by possible over- or undersmoothing as a consequence of rule of thumb based bandwidth selection. In the light of the latter caveats, we decide in favor of some resampling from the data which, similar to pairwise bootstrapping (Freedman 1981), promises valid significance levels even in case of local under- or oversmoothing. In the framework of parametric functional specifications Herwartz and Xu (2007) illustrate that residual based resampling is outperformed by the latter approach to resampling. The adopted approach to contrast a structurally invariant model against the local formalization is implemented along the following lines:

1) The local estimate in (12) can be seen as a function of the data and the chosen bandwidth parameter, i.e.

$$\hat{\boldsymbol{\beta}}(\omega) = f\{y_{it}, x'_{it}, \omega_{it} = (w_{it}^{(i)}, w_{it}^{(t)}), h, \; i = 1, \ldots, N, \; t = 1, \ldots, T\}. \tag{13}$$

2) To distinguish the cases of factor dependence and factor invariance of the SI relation we compare local estimates as given in (13) with bootstrap counterparts

$$\hat{\boldsymbol{\beta}}^*(\omega) = f\{y_{it}, x'_{it}, \omega^*_{it} = (w_{it}^{(i*)}, w_{it}^{(t*)}), h, \; i = 1, \ldots, N, \; t = 1, \ldots, T\}, \tag{14}$$

where bivariate tuples $\omega^*_{it} = (w^{(i*)}_{it}, w^{(t*)}_{it})$ are drawn with replacement from the set of bivariate variables $w_{it} = (w^{(i)}_{it}, w^{(t)}_{it})$. Since sample information on the y_{it} and x'_{it} is not affected by the bootstrap the adopted scheme will disconnect any potential link between the selected factor variable on the one hand and the SI relation on the other hand. If the true underlying SI relation is state invariant estimates $\hat{\boldsymbol{\beta}}(\omega)$ and $\hat{\boldsymbol{\beta}}^*(\omega)$ are likely to differ only marginally over the support of the state variable.

3) Drawing a large number, $R = 1000$ say, of bootstrap estimates $\hat{\boldsymbol{\beta}}^*(\omega)$ allows to decide if the null hypothesis of a state invariant SI relation can be rejected at some state $\omega = (w^{(i)}, w^{(t)})$. For this purpose, estimates $\hat{\beta}(\omega)$ are contrasted with a confidence interval constructed from its bootstrap distribution $\hat{\beta}^*(\omega)$. For this study, we will use the 2.5% and 97.5% quantiles of $\hat{\beta}^*(\omega)$ as a 95% confidence interval to hold for the parameter β under the null hypothesis of state invariance. Accordingly, we regard the actual estimate to differ locally from the unconditional relation with 5% significance if $\hat{\beta}(\omega)$ is not covered by the bootstrap confidence interval.

Alternatively, state dependent and invariant model representations could be contrasted by means of cross-validation (CV) criteria (Allen 1974, Stone 1974, Geisser 1975). The latter is seen as an out-of-sample based means to distinguish the relative merits of competing models that is not trivially affected by outstanding factors as e.g. the number of model parameters. Since semiparametric estimates could become quite wiggly in the boundaries of the factor support, we provide CV measures only for those observations which correspond to 'regular' factor realizations such that

$$cv_{(mod)} = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}|y_{it} - \hat{y}_{it}(mod)| I(-2 \leq w^{(t)}_{it} \leq 2) I(-2 \leq w^{(i)}_{it} \leq 2), \qquad (15)$$

where $I(\bullet)$ is an indicator function and *mod* refers either to state dependent or independent models. In (15) 'forecasts' $\hat{y}_{it}(mod)$ for the dependent variable are based on so-called leave one out or jackknife estimators, i.e.

$$\hat{y}_{it}(mod) = x'_{it}\underline{\hat{\boldsymbol{\beta}}}_{mod,it}, \qquad (16)$$

with $\underline{\hat{\boldsymbol{\beta}}}_{mod,it}$, being an estimated parameter vector that is obtained from a particular model, $y_{it} = x'_{it}\underline{\hat{\boldsymbol{\beta}}}_{mod,it} + e_{it}$, after removing the it-th pair of dependent and explanatory variables from the sample. Apart from model comparison by means of absolute forecast errors we will also consider CV criteria derived from squared forecast errors, i.e.

$$cv^2_{(mod)} = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}(y_{it} - \hat{y}_{it}(mod))^2. \qquad (17)$$

5 Results

In this section, we report results obtained from the state dependent model (9). Our discussion will not cover local estimates of the intercept $(\alpha(\omega))$ and trend parameter $(\delta(\omega))$

of the model. Rather we will concentrate on the empirical features of the SI relation, i.e. on local estimates $\hat{\beta}(\omega)$. As mentioned, the inclusion of a deterministic trend term in (9) was meant to allow an evaluation of factor impacts on the SI relation conditional on deterministic time features. We also estimated the local model excluding the deterministic trend term. Instead of providing any explicit results obtained from these exercises for space considerations, we confirm that functional relationships turn out to be invariant in shape under inclusion or exclusion of a deterministic trend variable. For most factors, however, slopes of functional forms were more pronounced for the model without deterministic trend. In addition, evaluating estimation uncertainty by means of resampling schemes obtains confidence intervals for the SI relation which are throughout wider for the functional regression model including the deterministic trend term.

5.1 Results for cross-validation comparison

For the three groups of factors considered, CV criteria comparing the merits of local estimates (12) against pooled regressions are reported in Table 3. Since the results from model comparison based on squared and absolute forecast errors are very similar, we only provide CV criteria for the latter. CV estimates for the semiparametric model are given in Table 3 as a fraction of the pooled regression (time invariant version of (9)) CV statistics.

As can be seen from Table 3, the relative performance of the functional coefficient model (9) against the pooled regression differs over the alternative cross sections as well as over the selected factor variables. For instance, used as a measure for capital market segmentation, an economies' real interest rate differential measured against some world index (for details see Section 5.2.2) does not help to improve the pooled model since the relative CV measures are close to unity throughout. With only a very few exceptions, all relative CV estimates are less than unity and thereby indicate some gain in jackknife forecasting offered by the local model. To assess the significance of the relative measure, one should take into account that, depending on the cross section, CV criteria are determined on the basis of a very large number of observations (up to 3100 for W97). Thus, moderate relative measures, varying between 0.90 and 0.97 say, may already signal a significant improvement of the invariant regression achieved by the local model. In some cases, the relative CV measures are clearly in favor of the local model. Conditioning, for instance, the SI relation on (the natural logarithm of) GDP when modeling F16 or E14 relative CV estimates are 0.74 and 0.75, respectively.

With regard to the larger cross sections W97 and L71, it is in particular the ratio of imports over GDP that provides the strongest improvement of the pooled model. For this factor variable the relative CV measures are 0.90 and 0.88 for W97 and L71, respectively.

With regard to model evaluation by means of CV criteria, it is worthwhile mentioning that the latter statistics indicate overall model performance. Even if relative CV estimates are smaller than but close to unity it is still possible that over particular areas of the factor space local estimates differ significantly from corresponding quantities computed under an assumption of global homogeneity. We turn now to the provision and discussion of local estimates of the SI relation.

5.2 Results for functional estimation

5.2.1 Factors impacting on saving, investment or the current account

Age dependency ratio

As displayed in the left hand side panels of Figure 3, the age dependency ratio affects significantly the SI relation in the long run for all displayed cross sections of developed countries (E11, F16, O26). Conditional on country specific long run trends ($w^{(i)} = 0$), the empirical SI relation is decreasing in the time specific age dependency ($w_{it}^{(t)} = (\widetilde{w}_{it} - \bar{w}_t)/\sigma_t(\tilde{w})$).

The observed negative impact of the age dependency ratio on the SI relation is consistent with the "Life Cycle Hypothesis" (LCH) suggested by Modigliani and Brumberg (1954). According to the latter theory, consumption or saving is affected by the age distribution of the population. Most households do not have a constant flow of income over their lifetimes. In order to smooth their consumption path, young agents should borrow and retired agents shall finance themselves from their past savings. Therefore, if the age dependency ratio, the ratio of the dependent population to the working-age population, is high, the aggregate saving rate shall be low. The latter might disconnect the links between domestic saving and investment. In the empirical literature (Modigliani 1970, Masson et al. 1998) the influence of the age dependency ratio on the saving ratio has been mainly confirmed by means of studies with cross-country or pooled data.

Regarding the level of the functional SI relations, it is worthwhile to point out that the between estimates given in Table 1 are likely not representative for the entire cross sections. For instance, the estimated between coefficient for E11, $\hat{\beta} = -0.11$, is far below the SI relation measured over states of a relatively low age dependency ratio. As such, homogeneous models like (1) run the risk of providing biased approximations of the link between domestic saving and investment. Note that the latter caveat of a homogeneous model formalization may also be illustrated with other potential factor variables.

For less developed economies (L71), the estimated SI relation shows a U-shaped behavior when interpreted as a function of the age dependency ratio. To explain the latter, one may conjecture that for less developed economies age dependency affects saving (consumption smoothing) and investment (growth prospect) in a more symmetric fashion than implied by the LCH for developed economies. As the most comprehensive cross section, the results for the long run SI relation given for W97 can be seen as an aggregate over the features of developed (O26) and less developed (L71) economies with the latter introducing some mild, i.e. insignificant, U-shaped pattern. In sum, the results for W97 underscore that the negative impact of age dependency on the SI relation dominates according to the significantly decreasing functional estimates over the factor support $-2 \leq w^{(t)} \leq 0.5$.

Effects of short run variations in the age dependency on the SI relation are not observed (medium panels of Figure 3). Conditional on ($w^{(t)} = -1, 0, 1$) the estimated functional forms are more or less constant. However, comparing conditional estimates for $w^{(t)} = 1$ and $w^{(t)} = -1$, it turns out that the former are almost uniformly above the latter for developed economies (E11, F16, O26). The right hand side panels show the difference between these two estimated short run effects, i.e. $\hat{\beta}(w^{(i)} = v, w^{(t)} = 1) - \hat{\beta}(w^{(i)} = v, w^{(t)} = -1)$, and the corresponding 95% confidence intervals. The significantly negative difference is confirmed for E11 and F16 over the supports $-1 \leq w^{(i)} \leq 1$ and for O26 given $-2 \leq w^{(i)} \leq 1.6$.

Similar to the latter results on the short run behavior of the SI relation conditional on age dependency, analyses conditional on other factors also reveal that the link between domestic saving and investment is mostly stable in response to inner country factor variation. For this reason, we will concentrate in the following on the functional relations characterizing the SI relation in the long run.

Population growth

Following Obstfeld (1986), population growth might govern saving as well as investment and thereby explain a high positive correlation between the latter variables. Long run effects of population growth on the SI relation for W97 are shown in the medium panel of Figure 6. Apart from boundary effects, the conditional estimates are well stabilized around the between estimates $\hat{\beta} = 0.43$ documented in Table 1. A clear trending pattern of the functional estimates cannot be diagnosed.

Per capita income

As a potential measure of an economies' state of development, the impact of global variation (W97) of per capita income on the SI relation is shown in the left hand side panel of Figure 6. From a-priori reasoning one may expect that for a less developed country, the domestic investment ratio is high in response to high rates of return, and the domestic saving ratio is lower owing to a high growth prospect. In contrast, for rich industrial economies with high per capita income, the domestic investment ratio is low because of low rates of return, and the domestic saving ratio is high owing to a low growth prospect. Hence, a hump-shaped SI relation is expected conditional on an increase of per capita income. Our empirical evidence on the impact of per capita income on the SI relation confirms the latter considerations merely to some extent. Conditional on economies having per capita income above the cross sectional average (W97), a significantly decreasing trend is visible from Figure 6. Functional estimates, similar to W97 in shape as well as in level, are found for L71. For the remaining cross sections a hump like pattern cannot be detected which might be addressed to a higher degree of factor homogeneity within these subsamples. For space considerations we do not show detailed estimation results obtained for per capita income.

Fiscal variables

Firstly, the government budget balance is considered as a fiscal variable which might have an influence on the SI relation. A full offset of private saving to government deficits (Ricardian equivalence) is generally rejected in the empirical literature. Bernheim (1987) shows that a unit increase in the government deficit is related with a decrease in consumption of 0.5 to 0.6. This evidence supports the view that government deficits might be positively correlated with current account deficits, thereby describing so-called "Twin Deficits". Based on this argument, we shall expect a hump-shaped SI relation conditional on an increasing government budget balance since a high current account imbalance is consistent with a low SI relation. As can be seen in the left hand side panels of Figure 4, hump-shaped functional estimates of the SI relation are only observed to some extent. While a significant left part of a hump shape is found for developed economies (O26), the right part is found to be significant for less developed economies (L71). However, a significant influence of the government budget balance on the SI relation is not observed for W97.

In the second place, we consider the influence of the composition of government expenditures on the SI relation. As can be seen from the upper right hand side panel of Figure 4, a significantly decreasing estimated SI relation is obtained for W97 conditional on increasing total government expenditure. For the remaining cross-sections, similar effects are found. A high government deficit spending might higher interest rates, and thus crowd out private investment and induce an increase in private saving. Furthermore, a partial offset of private saving to government deficit spending due to the expectation of increasing future tax may provoke a further increase in private saving. Therefore, high government spending might be related with a low SI relation. When we decompose total government expenditures to government capital, current and consumption expenditure for W97, significantly decreasing functional estimates are also obtained for the latter two components (the lower right hand side panels in Figure 4). Since government capital expenditure is generally viewed as productive, increasing future taxes might not be expected, which leaves private saving unaffected. Therefore, no significant influence of the government capital expenditure on the SI relation is observed.

5.2.2 Factors measuring integration of goods and financial markets

Openness

Conditioning the SI relation on the long run path of an economies' openness measured as the sum of imports and exports over GDP obtains significantly decreasing functional estimates for W97 (Figure 5). The latter reflects that domestic investment is naturally bounded by domestic saving for a closed economy. Separating W97 in its two divisions O26 and L71, we find that the overall trend is most obvious for the group of less developed economies. The latter impression might mirror that L71 is likely more heterogenous with regard to country specific degrees of openness. When alternatively decomposing the openness measure in its two components, exports over GDP and imports over GDP, we obtain that the common factor results documented for more closed economies ($-2 < w^{(t)} < -1$) are most obvious for the import over GDP measure. At the opposite, for more open economies ($1 < w^{(t)} < 2$), it appears to be the export over GDP component having the strongest impact on the SI relation evaluated conditional on openness. By construction, the 'openness' variable is a measure reflecting good markets integration. As such, our results for the conditional SI relation motivate the view that the SI relation is perhaps not only reflecting capital market separation as stated by FH (1980) but also barriers of international trade (Obstfeld and Rogoff 2000).

Interest rate parity

Having discussed the impact of openness as a measure of good markets integration on the SI relation it is also tempting to relate the latter to some measure approximating capital market integration. For this purpose we use the absolute real interest rate differential measured for a particular economy towards a world real interest rate index. Country specific real interest rates are the lending rates charged by banks on loans to prime customers adjusted for inflation. To approximate the real world interest rate we construct a GDP weighted average of real interest rates among the US, Germany and Japan. Instead of using the interest rate differential directly we presume that positive and negative realizations are equally informative for the prevalence of capital market frictions. Therefore we investigate the impact of the absolute real interest differential on the SI relation. As documented in the right hand side panel of Figure 6, a significant impact of the real interest rate differential on the SI relation for W97 is not found in our analysis for the global perspective which is also representative for all remaining cross sections (not shown for space considerations). Still, however, one may regard the different unconditional levels of empirical SI relations as reported in Table 1, for E11 against O15 say, to signal a mitigating impact of market integration on the SI relation.

By using the real interest rate differential, we are aware that this measure might not only correspond to capital mobility, as argued by Frankel (1992). As another potential measure of capital mobility, we consider the nominal interest rate differential. However, significant impacts of this measure on the SI relation are not obtained.

5.2.3 Large country effect

As can be seen in Figure 7, significantly positive long run impacts of the log GDP on the SI relation can be diagnosed for E11, O26 and W97, thereby supporting a large country effect. A large country might have a higher SI relation than a small country owing to an endogenous domestic interest rate. For the cross section of less developed economies we cannot confirm a large country effect which might be expected given that L71 collects small economies by definition.

To summarize, according to functional coefficient estimation the SI relation is found to be rather stable in the short run, but factor dependent in the long run. A low SI relation might be due to a high degree of the trade openness, high age dependency ratio, or high government current and consumption expenditures. In addition, small countries tend to have a lower SI relation in comparison with larger economies.

5.3 Implications

In light of the diagnosed factor dependent nature of empirical SI relations it is natural to address its' potential implications. We discuss two issues in turn.

Firstly, the increasing integration of capital markets alone does not automatically decrease the correlation between domestic saving and investment. The integration of global capital markets is necessary but not sufficient for a high net capital in(out)-flow and thus a low SI relation. The extent to which the domestic saving and investment are disconnected is depending on variables as the openness ratio, the age dependency ratio and government current and consumptions expenditures according to our analysis. Economies with high age dependency ratios or high exports have more money to lend and thus seek internationally the highest return. Comparably, economies with high government consumption and current expenditures or high imports might have more incentive to borrow internationally at the lowest costs. For these economies the SI relation may be low.

Secondly, since a low SI relation tend to correspond to a high current account imbalance, determinants of the SI relation can also be regarded as determinants of the current account. Based on our results, high government current and consumption expenditure may induce a high current account imbalance for most economies. For OECD countries, a high current account imbalance might also mirror a high age dependency ratio. Furthermore, the increasing degree of openness in good markets might provide countries with the possibility to sustain long run current account imbalances.

6 Conclusions

In this paper we investigate the relation between domestic saving and investment for seven cross sections covering the sample period 1971 to 2002. A new framework of bivariate functional coefficient models is applied to estimate conditional SI relations. We propose a resampling scheme to address inferential issues for the new model. Our bivariate functional approach allows to separate factor dependence of the SI relation in the short and long run. In the short run, the factor dependent SI relations are found to be rather stable. In the long run, however, a set of economic factors is found to impact the SI relation. The latter are an economies' openness ratio, the age dependency ratio and government expenditures. Supporting evidence for the large country effect on the SI relation is also found. Since the SI relation can be influenced by other macroeconomic variables than financial market integration, it might be inappropriate to learn about international capital mobility from saving and investment data.

Appendix 1. List of factors

Group 1:

- AGE: Ratio of the dependent population (younger than 15 and older than 64) to the working-age population (between 15 and 64) (%)
- GDPC: Natural logarithm of GDP per capita
- POPG: Growth rate of the population (%)
- GVBB: Ratio of government overall budget balance (including grants) to GDP (%)
- GVTT: Ratio of government total expenditure to GDP (%)
- GVIVM: Ratio of government capital expenditure to GDP (%)
- GVCE: Ratio of government current expenditure to GDP (%)
- GVCON: Ratio of government consumption expenditure to GDP (%)

Group 2:

- OPN: Ratio of export plus import to GDP (%)
- EXPT: Ratio of exports of goods and services to GDP (%)
- IMPT: Ratio of imports of goods and services to GDP (%)
- INTD: Absolute real interest rate differential measured for a particular economy towards a world real interest rate index (%)

Group 3:

- GDP: Natural logarithm of GDP

Appendix 2. List of countries included in W97

Algeria; Argentina; Australia; Austria; Bangladesh; Barbados; Belgium; Benin; Botswana; Brazil; Burkina Faso; Burundi; Cameroon; Canada; Central African Republic; Chile; China; Colombia; Congo Dem. Rep.; Congo Rep.; Costa Rica; Cote d'Ivoire; Denmark; Dominican Republic; Ecuador; Egypt Arab Rep.; El Salvador; Fiji; Finland; France; Gabon; Gambia; Germany; Ghana; Greece; Guatemala; Guyana; Haiti; Honduras; Hong Kong, China; Hungary; Iceland; India; Indonesia; Ireland; Israel; Italy; Jamaica; Japan; Kenya; Korea, Rep.; Kuwait; Luxembourg; Madagascar; Malawi; Malaysia; Mali; Malta; Mauritania; Mexico; Morocco; Myanmar; Nepal; Netherlands; New Zealand; Niger; Nigeria; Norway; Pakistan; Paraguay; Peru; Philippines; Portugal; Rwanda; Saudi Arabia; Senegal; Singapore; South Africa; Spain; Sri Lanka; Suriname; Swaziland; Sweden; Switzerland; Syrian Arab Republic; Thailand; Togo; Trinidad and Tobago; Tunisia; Turkey; Uganda; United Kingdom; United States; Uruguay; Venezuela, RB; Zambia; Zimbabwe.

References

Abbott, A. and Vita, G. D. (2003). Another piece in the Feldstein-Horioka puzzle, *Scottish Journal of Political Economy* **50**: 69–89.

AmirKhalkhali, S., Dar, A. A. and AmirKhalkhali, S. (2003). Saving-investment correlations, capital mobility and crowding out: some further results, *Economic Modelling* **20**: 1137–1149.

Artis, M. and Bayoumi, T. (1992). Global capital market integration and the current account, *in* M. Taylor (ed.), *Money and Financial Markets*, Cambridge, MS and Oxford: Blackwell, pp. 297–307.

Backus, D., Kehoe, P. and Kydland, F. (1992). International real business cycles, *Journal of Political Economy* **100**: 745–775.

Bajo-Rubio, O. (1998). The saving-investment correlation revisited: The case of Spain, 1964-1994, *Applied Economics Letters* **5**: 769–772.

Bernheim, B. D. (1987). Ricardian equivalence: An evaluation of theory and evidence, *NBER Macroeconomics Annual 1987*, Cambridge, Mass.: MIT Press.

Blanchard, O. and Giavazzi, F. (2002). Current account deficits in the euro area. the end of the feldstein horioka puzzle?, *MIT Department of Economics Working Paper 03-05*.

Cai, Z., Fan, J. and Yao, Q. (2000). Functional-coefficient regression models for nonlinear time series, *Journal of the American Statistical Association* **95**: 941–956.

Chinn, M. and Prasad, E. S. (2003). Medium-term determinants of current accounts in industrial and developing countries: An empirical exploration, *Journal of International Economcis* **59**: 47–76.

Coakley, J., Fuertes, A.-M. and Spagnolo, F. (2004). Is the Feldstein-Horioka puzzle history?, *The Manchester School* **72**: 569–590.

Coakley, J., Kulasi, F. and Smith, R. (1996). Current account solvency and the Feldstein-Horioka puzzle, *Economic Journal* **106**: 620–627.

Coakley, J., Kulasi, F. and Smith, R. (1998). The Feldstein-Horioka puzzle and capital mobility: A review, *International Journal of Finance and Economics* **3**: 169–188.

Coiteux, M. and Olivier, S. (2000). The saving retention coefficient in the long run and in the short run, *Journal of International Money and Finance* **19**: 535–548.

Debelle, G. and Faruqee, H. (1996). What determines the current account? a cross-sectional and panel approach, *Technical Report 96/58*, IMF Working Papers.

Edwards, S. (1995). Why are saving rates so different across countries?: An international comparative analysis, *NBER Working Paper 5097*.

Feldstein, M. and Horioka, C. (1980). Domestic saving and international capital flows, *Economic Journal* **90**: 314–329.

Frankel, J. A. (1992). Measuring international capital mobility: A review, *American Economic Review* **82**(2): 197–202.

Freedman, D. A. (1981). Bootstrapping regression models, *The Annals of Statistics* **9**: 1218–1228.

French, K. and Poterba, J. (1991). Investor diversification and international equity markets, *American Economic Review* **81**: 222–226.

Gulley, O. D. (1992). Are saving and investment cointegrated?, *Economics Letters* **39**: 55–58.

Haan, J. D. and Siermann, C. L. (1994). Saving, investment, and capital mobility. a comment on Leachman, *Open economies review* **5**: 5–17.

Härdle, W., Hall, P. and Marron, J. S. (1988). How far are automatically chosen regression smoothing parameters from their optimum?, *Journal of the American Statistical Association* **83**: 86–99.

Herwartz, H. and Xu, F. (2006a). Panel data model comparison for the investigation of the saving-investment relation, *Economics Working Paper 2006-06*, Christian-Albrechts-University of Kiel.

Herwartz, H. and Xu, F. (2006b). Reviewing the sustainability/stationarity of current account imbalances with tests for bounded integration, *Economics Working Paper 2006-07*, Christian-Albrechts-University of Kiel.

Herwartz, H. and Xu, F. (2007). A new approach to bootstrap inference in functional coefficient models, *Economics Working Paper 2007-15*, Christian-Albrechts-University of Kiel.

Ho, T.-W. (2002a). The Feldstein-Horioka puzzle revisited, *Journal of International Money and Finance* **21**: 555–564.

Ho, T.-W. (2002b). A panel cointegration approach to the investment-saving correlation, *Empirical Economics* **27**: 91–100.

Hodrick, R. J. and Prescott, E. C. (1997). Postwar u.s. business cycles: An empirical investigation, *Journal of Money, Credit and Banking* **29**: 1–16.

Jansen, W. J. (1996). Estimating saving-investment correlations: evidence for OECD countries based on an error correction model, *Journal of International Money and Finance* **15**: 749–781.

Jansen, W. J. (1997). Can the intertemporal budget constraint explain the Feldstein-Horioka puzzle?, *Economics Letter* **56**: 77–83.

Jansen, W. J. (1998). Interpreting saving-investment correlations, *Open Economies Review* **9**: 205–217.

Jansen, W. J. and Schulze, G. G. (1996). Theory-based measurement of the saving-investment correlation with an application to norway, *Economic Inquiry* **34**: 116–132.

Kasuga, H. (2004). Saving-investment correlations in developing countries, *Economics Letters* **83**: 371–376.

Leachman, L. L. (1991). Saving, investment, and capital mobility among OECD countries, *Open economies review* **2**: 137–163.

Lemmen, J. J. and Eijffinger, S. C. (1995). The quantity approach to financial integration: The Feldstein-Horioka criterion revisited, *Open economies review* **6**: 145–165.

Masson, P. R., Bayoumi, T. and Samiei, H. (1998). International evidence on the determinants of private saving, *The World Bank Economic Review* **12**: 483–501.

Mendoza, E. G. (1991). Real business cycles in a small open economy, *American Economic Review* **81**: 797–818.

Milesi-Ferretti, G. M. and Razin, A. (1997). Sharp reductions in current account deficits: An empirical analysis, *NBER Working Paper 6310*.

Milesi-Ferretti, G. M. and Razin, A. (1998). Current account reversals and currency crises: Empirical regularities, *NBER Working Paper 6620.*

Miller, S. M. (1988). Are saving and investment cointegrated?, *Economics Letters* **27**: 31–34.

Modigliani, F. (1970). The life-cycle hypothesis of saving and intercountry differences in the saving ratio, *in* W. Eltis, M. Scorr and J. Wolfe (eds), *Induction, Trade, and Growth: Essays in Honour of Sir Roy Harrod*, Clarendon Press, Oxford.

Modigliani, F. and Brumberg, R. (1954). Utility analysis and the consumption function: An interpretation of cross-section data, *in* K. K. Kurihara (ed.), *Post-Keynesian Economics*, Rutgers University Press.

Moreno, R. (1997). Saving-investment dynamics and capital mobility in the Us and Japan, *Journal of International Money and Finance* **16**: 837–863.

Nadaraya, E. A. (1964). On estimating regression, *Theory of Probability and its Applications* **10**: 186–190.

Obstfeld, M. (1986). Capital mobility in the world economy: Theory and measurement, *Carnegie-Rochester Conference Series on Public Policy* **24**: 55–104.

Obstfeld, M. and Rogoff, K. (2000). The six major puzzles in international macroeconomics: Is there a common cause?, *in* B. S. Bernanke and K. Rogoff (eds), *NBER Macroeconomics Anuual 2000*, The MIT Press, pp. 339–390.

Özmen, E. and Parmaksiz, K. (2003a). Exchange rate regimes and the Feldstein-Horioka puzzle: The Freanch evidence, *Applied Economics* **35**: 217–222.

Özmen, E. and Parmaksiz, K. (2003b). Policy regime change and the Feldstein-Horioka puzzle: The UK evidence, *Journal of Policy Modeling* **25**: 137–149.

Pelagidis, T. and Mastroyiannis, T. (2003). The saving-investment correlation in greece, 1960-1970: Implications for capital mobility, *Journal of Policy Modeling* **25**: 609–616.

Pelgrin, F. and Schich, S. (2004). National saving-investment dynamics and international capital mobility, *Working Paper 2004-14*, Bank of Canada.

Ravn, M. O. and Uhlig, H. (2002). On adjusting the HP-filter for the frequency of observations, *Review of Economics and Statistics* **84**: 371–380.

Sachsida, A. and Caetano, M. A.-R. (2000). The Feldstein-Horioka puzzle revisited, *Economics Letters* **68**: 85–88.

Schmidt, M. B. (2001). Savings and investment: Some international perspectives, *Sourthern Economic Journal* **68**: 446–456.

Scott, D. W. (1992). *Multivariate Density Estimation: Theory, Practice, and Visualization*, John Wiley & Sons, New York, Chichester.

Sinha, T. and Sinha, D. (2004). The mother of all puzzles would not go away, *Economics Letters* **82**: 259–267.

Sinn, S. (1992). Saving-investment correlations and capital mobility: On the evidence from annual data, *Economic Journal* **102**: 1162–1170.

Summers, L. H. (1988). Tax policy and international competitiveness, *in* J. Frankel (ed.), *International Aspects of Fiscal Polices*, Chicago: University of Chicago Press, pp. 349–386.

Taylor, A. M. (1996). International capital mobility in history: The saving-investment relationship, *NBER Working Paper 5743*.

Taylor, A. M. (1998). Argentina and the world capital market: Saving, investment, and international capital mobility in the twentieth centruy, *Journal of Development Economics* **57**: 147–184.

Taylor, A. M. (2002). A century of current account dynamics, *Journal of International Money and Finance* **21**: 725–748.

Tesar, L. L. (1993). International rsik-sharing and non-traded goods, *Journal of International Economics* **35**: 69–89.

Vita, G. D. and Abbott, A. (2002). Are saving and investment cointegrated? an ardl bounds testing approach, *Economics Letters* **77**: 293–299.

Watson, G. (1964). Smooth regression analysis, *Sankhyā, Series A,* **26**: 359–372.

Table 1: **Between regression**

$$\overline{I_i^*} = \alpha + \beta \overline{S_i^*} + e_i$$

Samples	W97	L71	O26	O15	F16	E14	E11
			Panel A: 1971 - 2002				
$\widehat{\beta}$	**0.43**	**0.42**	**0.59**	**0.77**	**0.62**	0.13	−0.16
	(11.24)	(9.37)	(5.11)	(7.96)	(4.44)	(0.53)	(−0.71)
R^2	0.57	0.56	0.52	0.83	0.58	0.02	0.05
			Panel B: 1971 - 1986				
$\widehat{\beta}$	**0.44**	**0.42**	**0.69**	**0.86**	**0.66**	0.36	0.18
	(9.44)	(7.54)	(6.58)	(10.43)	(4.50)	(1.46)	(0.78)
R^2	0.48	0.45	0.64	0.89	0.59	0.15	0.06
			Panel C: 1987 - 2002				
$\widehat{\beta}$	**0.38**	**0.39**	**0.39**	**0.65**	**0.30**	−0.02	−0.14
	(9.96)	(8.76)	(3.27)	(5.23)	(2.24)	(−0.10)	(−0.90)
R^2	0.51	0.53	0.31	0.68	0.26	0.00	0.08

This table reports slope estimates from the between regressions of the investment ratio on the saving ratio. t-statistics appear in parentheses below the coefficient estimates. Coefficients which are significant at the 5% level are highlighted in bold face.

Table 2: **Parametric factor dependence of the SI relation**

$$\hat{\gamma}_1 \text{ in } \hat{\beta}_i = \gamma_0 + \gamma_1 \bar{w}_i + u_i$$

Factor	W97	L71	O26	O15	F16	E14	E11
AGE	**−0.006**	0.001	**−0.026**	−0.018	**−0.052**	**−0.060**	**−0.068**
	(−2.51)	(0.15)	(−2.41)	(−1.48)	(−2.52)	(−2.26)	(−2.57)
OPN	**−0.004**	**−0.004**	−0.005	0.000	−0.006	**−0.009**	**−0.009**
	(−3.84)	(−3.41)	(−1.53)	(0.06)	(−2.10)	(−2.68)	(−2.93)
EXPT	**−0.007**	**−0.007**	−0.009	−0.000	−0.011	**−0.016**	**−0.017**
	(−3.53)	(−3.23)	(−1.54)	(−0.03)	(−2.04)	(−2.55)	(−2.68)
IMPT	**−0.009**	**−0.007**	−0.010	0.002	−0.012	**−0.019**	**−0.020**
	(−4.05)	(−3.50)	(−1.50)	(0.16)	(−2.14)	(−2.79)	(−3.18)
t-critical value at 5%	1.985	1.994	2.064	2.131	2.145	2.179	2.262

OLS slope estimates for profile regressions (3). t-statistics appear in the parentheses below the coefficient estimates. Coefficient estimates which are significant at the 5% level are highlighted in bold face. A list of abbreviations for the employed factor variables is given in the Appendix.

Table 3: **Factor dependent model comparison**

Factor	W97	L71	O26	O15	F16	E14	E11
			Group 1				
AGE	0.97	0.98	0.92	0.93	0.94	0.96	0.94
GDPC	0.95	0.93	0.79	0.89	0.86	0.75	0.74
POPG	0.99	1.00	0.98	0.91	0.95	0.91	0.93
GVBB	0.99	0.99	0.96	0.97	0.92	0.96	1.02
GVTT	0.96	0.96	0.91	0.91	0.87	0.87	0.86
GVIVM	0.96	0.96	0.97	0.97	0.95	0.92	0.92
GVCE	0.97	0.98	0.90	0.92	0.87	0.86	0.85
GVCON	0.96	0.97	0.87	0.89	0.82	0.84	0.91
			Group 2				
OPN	0.93	0.93	0.94	0.86	0.83	0.98	0.91
EXPT	0.94	0.93	0.90	0.81	0.81	0.97	0.96
IMPT	0.90	0.88	0.89	0.82	0.84	0.93	0.87
INTD	1.01	1.00	1.00	1.04	0.98	1.00	1.02
			Group 3				
GDP	0.95	0.98	0.89	0.92	0.74	0.75	0.78

This table reports CV criteria (absolute forecast errors) comparing of local estimates (12) against the factor invariant trivariate regression. Semiparametric CV estimates are given as a fraction of the pooled regression CV statistics.

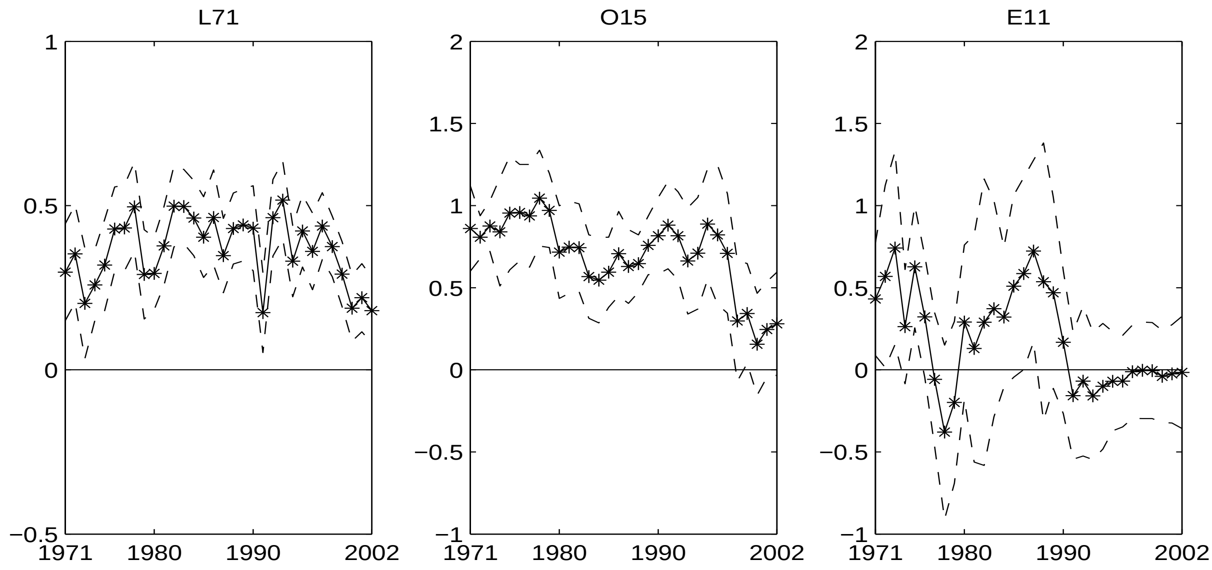

Figure 1: Estimated time varying SI relations obtained from model (2) for the three non-overlapping cross sections. The solid line with stars shows the point estimates and the two dashed lines are the corresponding 95% confidence intervals.

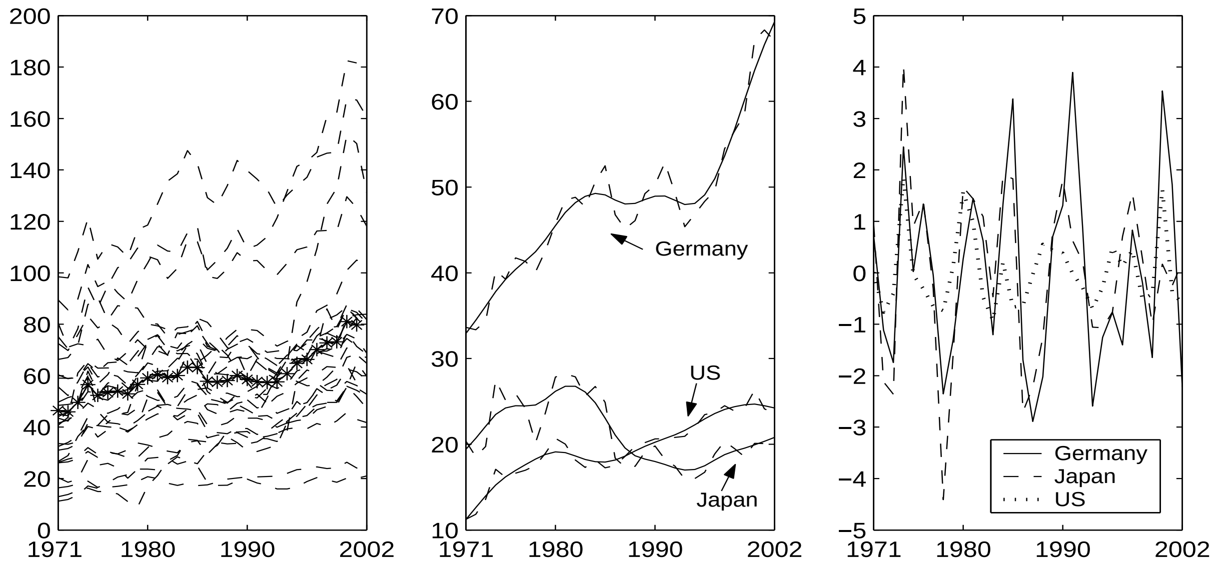

Figure 2: Dynamics of the openness ratio. The left hand side panel shows the observations for the countries in O26 (dashed line) and the corresponding cross-sectional averages (solid line with stars). The medium panel displays the openness degree of Germany, the US and Japan (dashed line), and the corresponding long run trend (solid line). The right hand side panel illustrates the deviations from the long run trend for the given three countries.

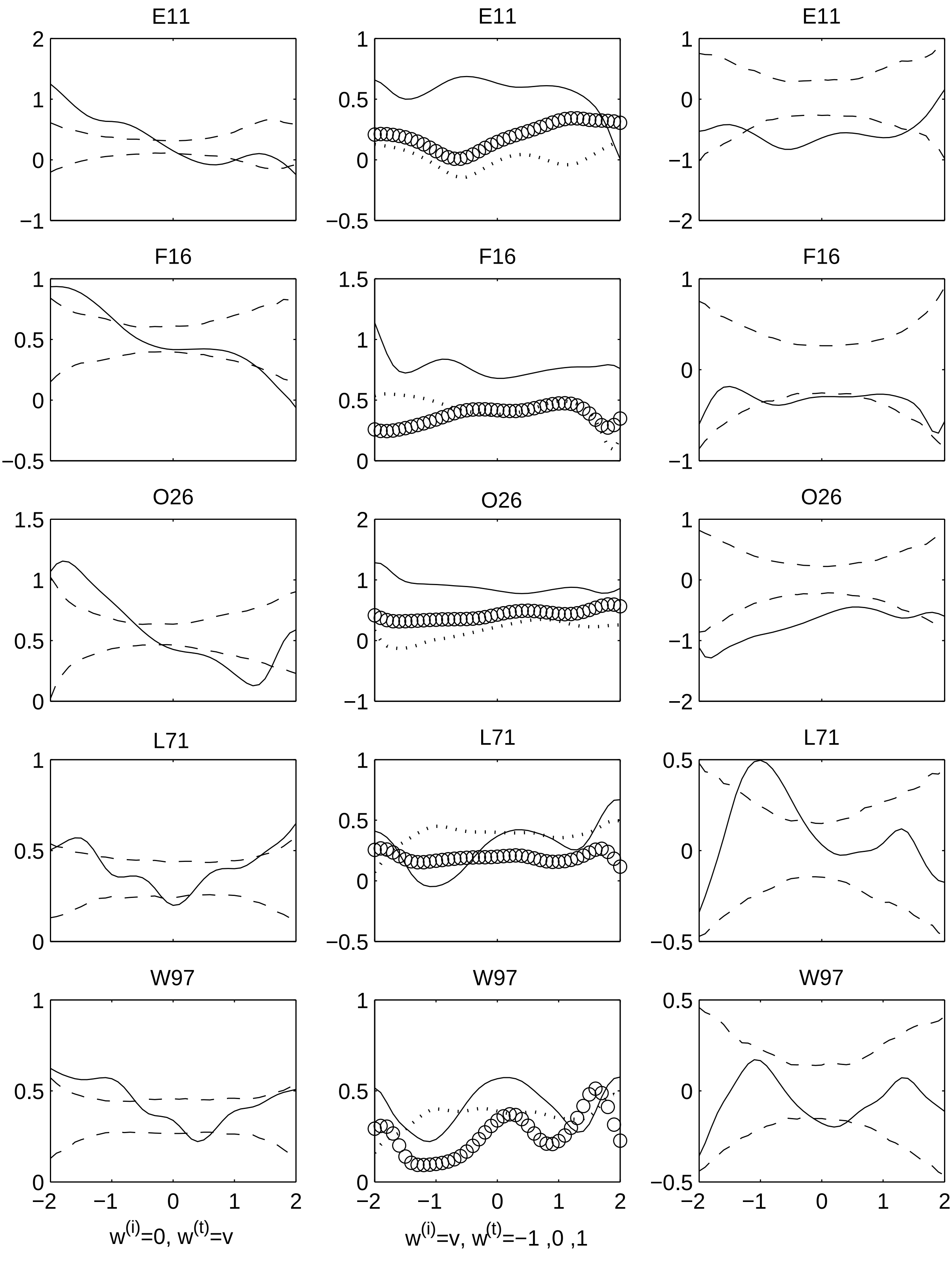

Figure 3: Functional estimates of the SI relation conditional on the age dependency ratio for five selected cross sections. The left hand side panels show the estimated long run effects $\hat{\beta}(w^{(i)} = 0, w^{(t)} = v)$ (solid). Dashed lines are the corresponding 95% confidence intervals. The medium panels display the short run effects for three local paths, i.e. $\hat{\beta}(w^{(i)} = v, w^{(t)} = 0)$ (circled line), $\hat{\beta}(w^{(i)} = v, w^{(t)} = -1)$ (solid) and $\hat{\beta}(w^{(i)} = v, w^{(t)} = 1)$ (dotted). The right hand side panels show the difference between two estimated short run effects (solid), i.e. $\hat{\beta}(w^{(i)} = v, w^{(t)} = 1) - \hat{\beta}(w^{(i)} = v, w^{(t)} = -1)$, and the corresponding 95% confidence intervals (dashed).

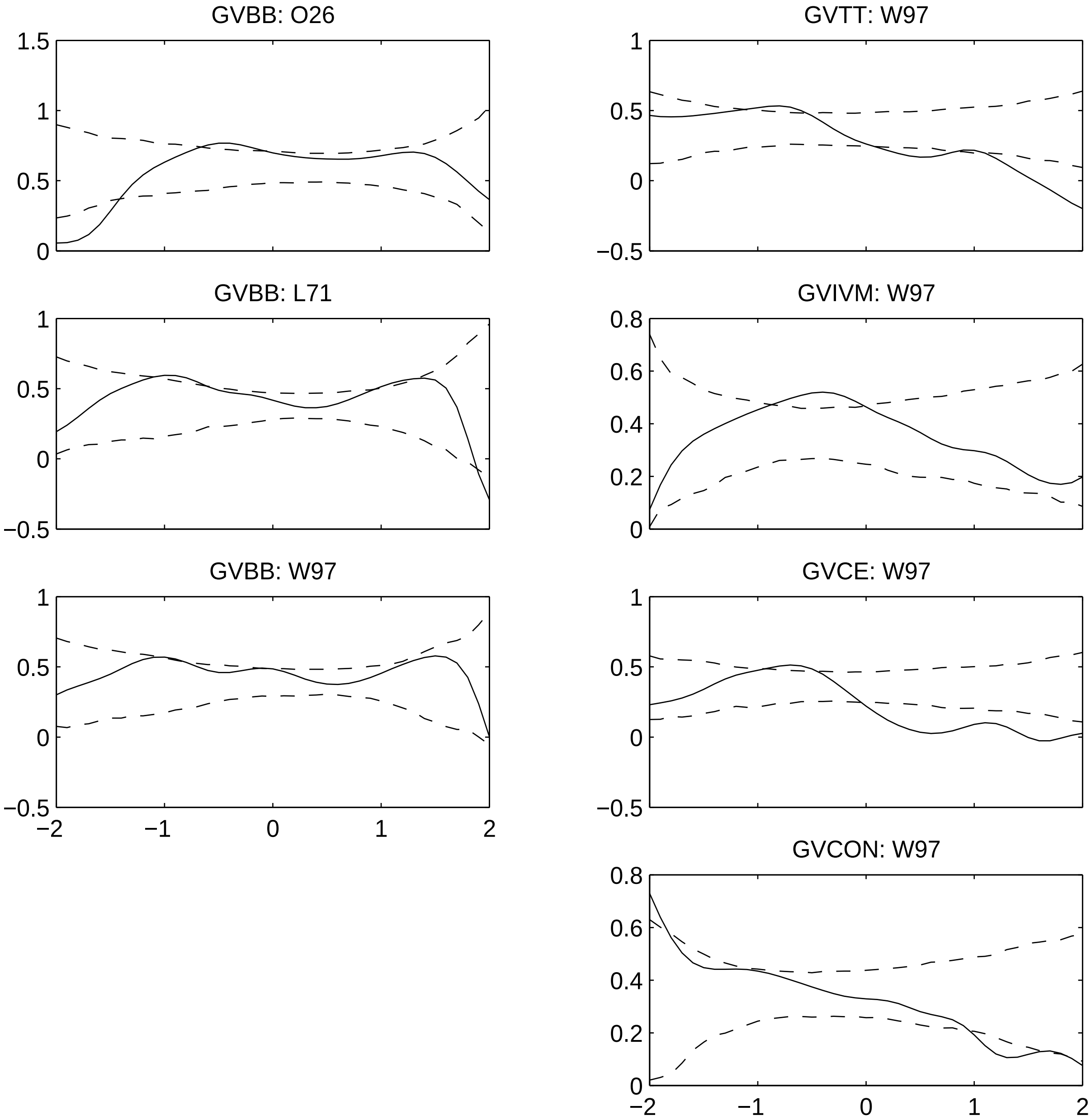

Figure 4: Functional estimates of the SI relation conditional on fiscal variables. The long run effects $\hat{\beta}(w^{(i)} = 0, w^{(t)} = v)$ are displayed. The solid line shows the point estimates and the dashed lines are the corresponding 95% confidence intervals.

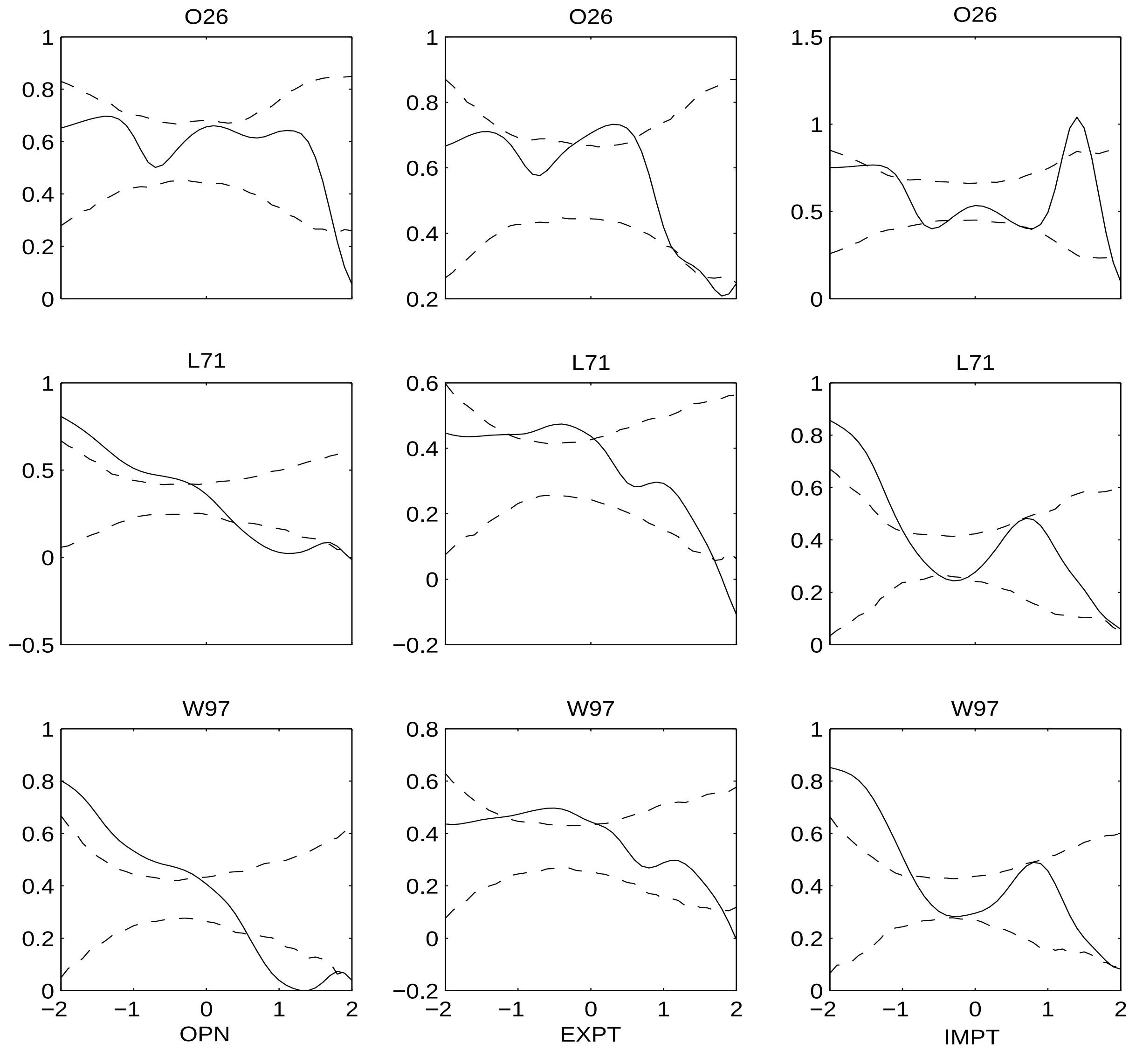

Figure 5: Functional estimates of the SI relation conditional on the openness ratio, the ratio of exports and imports to GDP for three selected cross sections. Estimated long run effects $\hat{\beta}(w^{(i)} = 0, w^{(t)} = v)$ are displayed. The solid line shows the point estimates and the two dashed lines are the corresponding 95% confidence intervals.

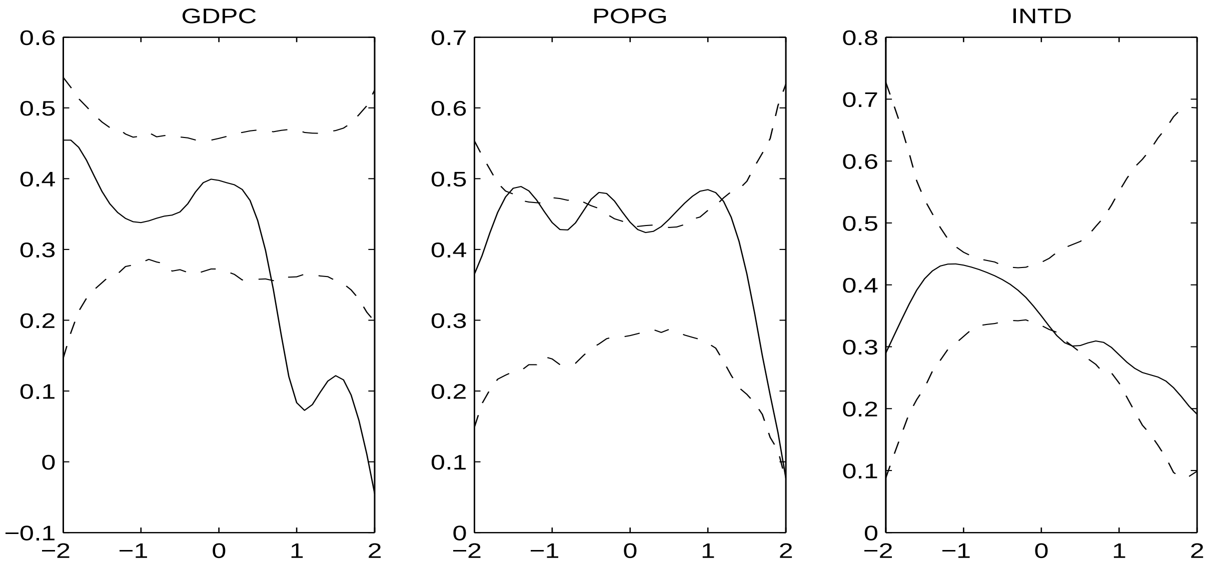

Figure 6: Functional estimates of the SI relation conditional on per capita income, the population growth rate and the absolute real interest rate differential. Estimated long run effects $\hat{\beta}(w^{(i)} = 0, w^{(t)} = v)$ are displayed for W97. The solid line shows the point estimates and the two dashed lines are the corresponding 95% confidence intervals.

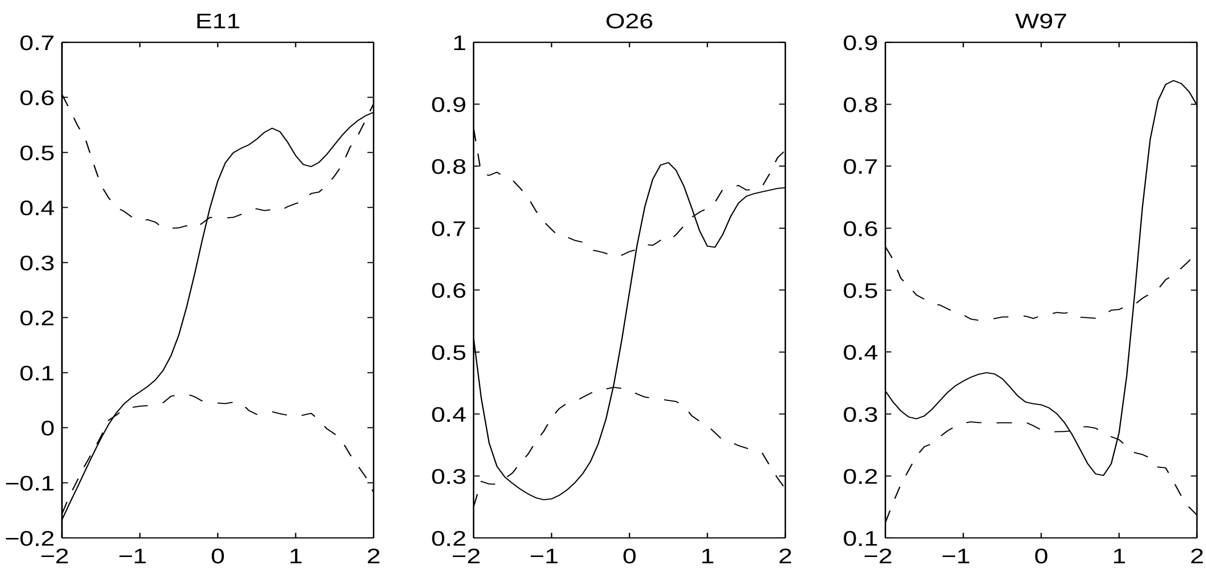

Figure 7: Functional estimates of the SI relation conditional on the logarithm of GDP. Estimated long run effects $\hat{\beta}(w^{(i)} = 0, w^{(t)} = v)$ are displayed. The solid line shows the point estimates and the two dashed lines are the corresponding 95% confidence intervals.